POSSIBILITIES OF APPLICATIONS OF ARTIFICIAL INTELLIGENCE IN DESIGN TECHNOLOGY AND ORGANIZATION OF CONSTRUCTION OF HIGH-SPEED RAIL

Polyanskiy, Aleksey V. *– Ph. D. (Tech.), assistant professor of the department of organization, technology and management of construction of Moscow State University of Railway Engineering (MIIT), Moscow, Russia*

ABSTRACT

The theoretical basis of application of methods of artificial intelligence (expert systems, artificial neural networks, genetic algorithms) to organizational and technological decisions in construction of high-speed rail is provided in the article. The author describes an efficient method for implementation of such decisions with the use of information model and system of management decisions on the results of the monitoring of the construction process.

ENGLISH SUMMARY

Background. *Need for development of Russian railways opens new opportunities in the transport construction, in particular in projection and creation of design, technological and organizational solutions. Concurrently high- speed traffic is one of the most important spheres. Development of this far reaching sphere is associated with working-out of project documentation, which must take into account the international and domestic experience in creating high-speed rail lines. As a result, the procedure of immediate organizational and technological solutions (OTS) in the construction of track superstructures, roadbed, catenary system, artificial structures, etc. is of a great interest.*

Objective. *The objective of the author is to introduce the application of artificial intelligence techniques in the context of organizational and technological solutions, and in particular, in the construction of high- speed rail.*

Methods. *The author uses theoretical basis in the field of artificial intelligence and with use of analysis and synthesis methods applies it to the practical issues of high- speed rail construction.*

Results.

I.

Obviously, the promptness in designing is achieved due to automation. Unfortunately, at present the selection and preparation of OTS in railway construction is carried out with minimal involvement of computing.

A comprehensive research showed that at all stages of the preparatory work arise problems that are not solved in an automated way, and this fact greatly extends time for working- out construction documents. This situation occurs due to insufficient development of decision-making procedures and their formalization.

The problem of synthesizing of OTS structure, for example, belongs to hard- formalizable tasks [1,2]. Hard- formalizable steps of OTS formation include [2]: the formation of construction processes, resource support, determining the sequence of transitions and optimization of OTS according to various criteria.

Existing systems of automated preparation for construction are based on the concept of active interaction with the engineer in dialog mode. Construction processes are created by a technologist, who relies on the selected structural and technological solution (STS), the system only provides him with reference data, operational information on the production, allows working with a database of construction (contractor) organization.

Although these systems facilitate the life of a technologist and enhance his efficiency, they are actually just electronic workplaces.

The rapid growth of information technology entailed a new milestone in the development of methods and tools designed to assist in the planning and organization of construction technology using a computer. Theoretical and practical advances in the field of artificial intelligence (AI) are of great interest here.

II.

Incorporation of intelligent software, agents or modules in the developed CAD systems, applied to OTS, enables to replace a technologist at many tasks, and provide search for innovative technological solutions [5]. This is achieved through a number of stages of intellectualization of the development and implementation of OTS (Pic. 1), the complexity of the formalization of which is connected with the peculiarities of human mental activity (associative thinking, the ability to think by analogy, intuitive selection, etc.). There are new tools: artificial neural networks (ANN), genetic algorithms (GA), expert systems (ES) [1].

Intellectualization of development stages of OTS sets as its ultimate goal creation of an information model (OTS model).

Pic. 2 is a functional block diagram of the design and implementation of OTS. There are four stages (blocks I.1, I.2, II.1, II.2): STS selection, design of OTS, forming a monitoring system for construction processes using the information model and the implementation of OTS on the monitoring results. Blocks I.1.1, I.1.2, I.1.4, I.2.1, II.1.1, II.1.2, 1–4 show the current state of the research problem; blocks I.1.3, I.1.5, I.1.6, I.2.2, I.2.3, I.2.4, I.2.5, II.2.1, II.2.2 reflect a far-reaching approach to solving a number of problems within the intellectualization of organizational and technological preparation for construction; blocks 5, 5.1–5.5 demonstrates database structure in which knowledge and experience in the design, management, organization and technology of transport (including rail) construction are accumulated, stored and correlate to each other in the form of thematic knowledge bases [3].

The use of AI techniques made possible the development of OTS in the complex, from the generation of construction processes to their multicriteria optimization with use of accumulated knowledge and experience in the field of transport construction. Mathematical modeling based on AI techniques largely eliminates gaps between the objective need for rational OTS, depth and increasing the promptness of their development, computing power of specialists and resources of engineering work that they previously had at their disposal. Moreover, an opportunity of rapid adjustment of OTS during the work appears.

The main stages, where application of intelligent technologies is natural, are: the development of construction processes, the solution of the task of resource support for construction processes, the formation of OTS structure, optimization of construction processes, the synthesis of OTS.

Selection of constructive and technological solution precedes the stage of OTS development OTP (Pic. 2).

The stage of construction processes development is based on the application of a production- type ES.

A distinctive feature of the proposed model of intellectual knowledge base for the design of construction processes is the fact that inference rules used in the productions are based on the regularities of three kinds: technological, organizational and system dependencies. Based on the principle of decomposition of the procedure of OTS forming, production models are presented in complex at the levels of complex and simple processes.

Solution of the problem of resource support of construction processes (Fig. 2) involves the use of ANN trained by back propagation algorithm. At this stage there is a choice of the most effective type of resources (performers and machinery) for each element of the process at complex process or simple process levels.

At the stage of formation of OTS structure and optimization of construction processes various methods of AI (Pic. 2) are applied: probability-recurrent and recurrent hybrid ANN with elements of fuzzy logic [3].

OTR synthesis phase is based on a mechanism of evolutionary optimization, in particular, genetic method of combining heuristics (GMCH) [4], which is based on GA (Pic. 2). The result is a schedule diagram based on the optimal parallelization of work and allocation of resources at a simple process level.

III.

As a result, there is OTS, which in turn serves as an information model for managing construction processes. Implementation of this task requires operational decisions in the implementation of construction processes. In order to ensure timely entry into operation of high speed rail in accordance with the design parameters of quality and safety, as well as the effective operation of construction organization, several features of construction processes' development should be taken into account.

This is explained by the fact that construction processes are a probabilistic system, subject to the influence of a number of factors: external and internal. Their influence has mostly a negative effect on the duration and quality of construction and entails a number of negative consequences (primarily – economic) for the construction organization.

In order to effectively implement the construction work, there are proposals for rapid working-out of management decisions based on the results of construction processes' monitoring (Pic. 3).

Development of management decisions on the results of construction processes' monitoring involves:

- registration of data on the scope of performed work at specified time periods;
- reliability assessment of OTS;
- *operational management decision-making to adjust construction processes in case of reducing the reliability of OTS.*

Reliability assessment of OTS is based on the mathematical tool of the theory of reliability (as applied to industrial processes), the methodology of transport construction management and decision-making techniques with the use of ES.

These requirements for monitoring of construction processes' development are based primarily on the time, required for analysis within construction processes' monitoring.

Implementation of some of the functions of monitoring and working-out of management solutions with the ability to improve their reliability can be achieved by using AI techniques. As a result, the construction organization will be able to commit (if necessary) «technological maneuvers», i. e. corrections or even a significant changes in construction processes with account of limitations.

Conclusion

In order to implement the provisions analyzed in the research and improve the theoretical validity of the proposed method, a specially designed intelligent analytical system (IAS) «Intention» and expansion packs for mathematical modeling and technical computing, Matlab – Neural Network Toolbox and the Genetic Algorithm and Direct Search Toolbox are used.

Application of proposed methods and means of developing and implementing of OTS in high speed rails construction, according to the information received, will provide construction organizations with the opportunity to effectively manage the production situation in order to achieve their own profitability and the quality of construction, which will undoubtedly have a positive impact on the reliability of transport facilities and train safety.

Key words: *organizational-technological decisions, railway construction, high-speed rail, construction process, artificial intelligence methods, expert system, artificial neural network, genetic algorithm, project management*

REFERENCES

1. Polyanskiy, A. V. Intelligent approaches to the development of rational organizational and technological solutions in transport construction [*Intellektual'nye podhody k razrabotke ratsional'nyh organizatsionno-tehnologicheskih resheniy v transportnom stroitel'stve*]. *Transportnoe stroitel'stvo*, 2013, Iss.10, pp. 13–15.

2. Computer-aided design for organization of railway construction [*Avtomatizirovannoe proektirovanie organizatsii stroitel'stva zheleznyh dorog*] ed. by S. P. Pershin. Moscow, Transport publ., 1991, 261 p.

3. Luger, George F. Artificial Intelligence: Structures and Strategies for Complex Problem Solving [*Russian title: Iskusstvennyj intellekt: strategii i metody resheniya slozhnyh problem*]. 4th ed.: transl. from English. Moscow, Williams publ., 2003, 864 p.

4. Norenkov, I. P. Heuristics and their combinations in the genetic methods of discrete optimization [*Evristiki i ih kombinatsii v geneticheskih metodah diskretnoy optimizatsii*]. *Informatsionnye tehnologii*, 1999, 1, pp. 2–7.

5. Kagan, P. B. Ways of improving the tools and techniques of organizational and technological design [*Puti sovershenstvovaniya sredstv i priemov organizatsionno-tehnologicheskogo proektirovaniya*]. *Promyshlennoe i grazhdanskoe stroitel'stvo*, 2011, 9, pp. 24–25.

Координаты автора (contact information): Полянский А. В. (Polyanskiy A.V.) – polal_82@mail.ru.
Статья поступила в редакцию / article received 28.11.2013
Принята к публикации / article accepted 03.02.2014